

System permits the user to teach the system new decision rules or to alter pre-existing rules judged to be inadequate or incorrect. Goals for further development of the system include expansion of the consultation program to deal with infections other than bacteremias and implementation and evaluation of the system in the clinical setting at Stanford University Hospital.

COMPUTING APPLIED TO PROTEIN CRYSTALLOGRAPHY

Members of the artificial intelligence project at Stanford also are collaborating with Professor Joseph Kraut and Dr. Stephan Freer, protein crystallographers at the University of California, San Diego. They are using the SUMEX-AIM facility as the central repository for programs, data and other information of common interest. The general objective of the project is to apply problem-solving techniques, which have emerged from artificial intelligence research, to the well-known "phase problem" of x-ray crystallography in order to determine the three-dimensional structures of proteins. The work is intended to be of both practical and theoretical value to computer science (particularly artificial intelligence research) and protein crystallography.

DIALOG

The DIAGnostic LOGic project, under the direction of Dr. Harry Pople and Dr. Jack Myers at the University of Pittsburgh, is a large-scale, computerized medical diagnostic system utilizing the methods and structures of artificial intelligence. Unlike most computer diagnostic programs, which are oriented to differential diagnosis in a rather limited area, the DIALOG system deals with the general problem of diagnosis in internal medicine and currently accesses a medical data base encompassing approximately 50% of the major diseases in internal medicine.

MISL

The Medical Information Systems Laboratory at the University of Illinois at Chicago Circle has been established under the direction of Dr. Bruce McCormick, Information Engineering, in collaboration with Dr. Morton Goldberg, an ophthalmologist at the U of I medical school. The project explores inferential relationships between analytic data and the natural history of selected eye diseases both in treated and untreated forms. SUMEX-AIM will be utilized to build a data base to be used as a test bed for the development of clinical decision support algorithms.

DISTRIBUTED DATA-BASE SYSTEM FOR CHRONIC DISEASE

This project, based at the University of Hawaii, is under the

direction of Dr. Franklin Kuo of the Department of Electrical Engineering and Technical Director of the ALOHA System. It seeks to use SUMEX-AIM to establish a resource-sharing project for development of computer systems for consultation and research and to make these systems available to clinical facilities from a set of distributed data bases. Radio and satellite links composing the ALOHANET communication network, in conjunction with the ARPANET, will make these programs available to other Hawaiian islands and to remote areas of the Pacific basin. This project could have a significantly beneficial effect on the quality of health care delivery in these locations.

SUMEX-AIM Management

A significant part of the SUMEX-AIM experiment is the development of a management structure to maximize the utility of the computer capability for a national community.

Users of the SUMEX facility are divided for administrative purposes into two groups: 1) those at Stanford University School of Medicine, and 2) those elsewhere in the United States. The facility resources (computing capacity and consulting support) are allocated in equal portions to the two groups. As Principal Investigator for the SUMEX grant, Dr. Lederberg reviews Stanford medical school projects with the assistance of a local advisory committee. National users may gain access to the facility resources through an advisory panel for a national program in artificial intelligence in medicine (AIM). The AIM Advisory Group consists of members-at-large of the AI and medical communities, facility users and the Principal Investigator of SUMEX as an ex-officio member. A representative of the National Institutes of Health-Biotechnology Resources Branch (NIH-BRB) serves as Executive Secretary.

The SUMEX-AIM computing resource is initially allocated to qualified users without fee. This, of course, entails a careful review of the merits and priorities of proposed applications. At the direction of the Advisory Group, expenses related to communications and transportation to allow specific users to visit the facility may be covered as well.

SUMEX-AIM is aware of the necessity of making the facility available for trial use by potential users and collaborators. A GUEST mechanism has been established for those who have an indicated requirement for brief access to certain programs. Those who have been given an appropriate telephone number and login procedure can dial up SUMEX-AIM to exercise these programs on a trial basis.

USER QUALIFICATIONS

Applications for use of the SUMEX-AIM facility are judged on the basis of:

- 1) The scientific interest and merit of the proposed research.
- 2) The relevance of the research to the artificial intelligence approach of SUMEX-AIM as opposed to other computing alternatives.
- 3) The user's prospective contributions and role in the community, e.g., developing and sharing new systems or applications programs, sharing use of special hardware, etc.
- 4) The user's capability and intentions of operating in a community-effective style for mutual advantage. Besides the programming innovations that some participants may contribute, all are expected to furnish expert knowledge and advice about the existing art in their fields of interest.
- 5) The quantitative allocation of specific elements of the SUMEX-AIM resource based on a concept of mean and ceiling planned expectations.

FACILITY INFORMATION

The computer facility, consisting of a DEC Model KI-10 CPU running under the TENEX operating system, has 256K words (36-bit) of high-speed memory, 1.6M words of swapping storage, 70M words of disk storage, two 9-track 800 bpi industry-compatible tape units, a dual DEC-tape unit, a line printer, and communications-network interfaces providing user terminal access. SUMEX is available through TYMNET and as a host over the ARPANET communications network.

Program (software) support will evolve from the basic system as dictated by the research goals and needs of the user. Initially, available programs include a variety of TENEX user, utility and text editor programs. Major user languages include INTERLISP, SNOBOL, SAIL, FORTRAN-10, BLISS-10, BASIC, Macro-10, OMNIGRAPH and MLAB.

POTENTIAL USERS

For further information, write:

Elliott Levinthal, Ph.D.
 AIM User Liaison
 SUMEX-AIM Computer Project
 c/o Department of Genetics, S047
 Stanford University Medical Center
 Stanford, California 94305

Procedures for access to SUMEX-AIM are governed by the:

Biotechnology Resources Branch
Division of Research Resources
National Institutes of Health
Building 31, Room 5B19
Bethesda, Maryland 20014

APPENDIX I

Detailed Questionnaire for Prospective New Users

SUMEX-AIM RESOURCE
INFORMATION FOR POTENTIAL USERS

National users may gain access to the facility resources through an advisory panel for a national program in artificial intelligence in medicine (AIM). The AIM Advisory Group consists of members-at-large of the AI and medical communities, facility users and the Principal Investigator of SUMEX as an ex-officio member. A representative of the National Institutes of Health-Biotechnology Resources Branch (NIH-BRB) serves as Executive Secretary.

Under its enabling 5-year grant, the SUMEX-AIM resource is allocated to qualified users without fee. This, of course, entails a careful review of the merits and priorities of proposed applications. At the direction of the Advisory Group, expenses related to communications and transportation to allow specific users to visit the facility may be covered as well.

USER QUALIFICATIONS

In general terms, potential users of the SUMEX-AIM facility are judged on the basis of:

- 1) The scientific interest and merit of the proposed research.
- 2) The relevance of the research to the artificial intelligence approach of SUMEX-AIM as opposed to other computing alternatives.
- 3) The user's prospective contributions and role in the community, e.g., developing and sharing new systems or applications programs, sharing use of special hardware, etc.
- 4) The user's capability and intentions of operating in a community-effective style for mutual advantage. Besides the programming innovations that some participants may contribute, all are expected to furnish expert knowledge and advice about the existing art in their fields of interest.
- 5) The quantitative allocation of specific elements of the SUMEX-AIM resource based on a concept of mean and ceiling planned expectations.

In many respects, this requires a different kind of information for judgment of proposals than that required for routine grant applications seeking monetary funding support. Information furnished by users also is indispensable to the SUMEX staff in conducting their planning, reporting and operational functions.

The following questionnaire encompasses the main issues concerning the Advisory Group. However, this should neither obstruct clear and imaginative presentation nor restrict format of the application. The potential user should prepare a statement in his own words using previously published material or other documents where applicable. In this respect, the questionnaire may be most useful as a checklist and reference for finding in other documentation the most cogent replies to the questions raised.

For users mounting complex and especially nonstandard systems, the decision to affiliate with SUMEX may entail a heavy investment that would be at risk if the arrangement were suddenly terminated. The Advisory Group endeavors to follow a responsible and sensitive policy along these lines--one reason for cautious deliberation; and even in the harshest contingencies, it will make every effort to facilitate graceful entry and departure of qualified users. Conversely, it must have credible information about thoughtful plans for long-term requirements including eventual alternatives to SUMEX-AIM. SUMEX-AIM is a research resource, not an operational vehicle for health care. Many programs are expected to be investigated, developed and demonstrated on SUMEX-AIM with spinoffs for practical implementation on other systems. In some cases, the size, scope and probable validation of clinical trials would preclude their being undertaken on SUMEX-AIM as now constituted. Please be as explicit as possible in your plans for such outcomes.

Applicants, therefore, should submit:

- 1) One to two-page outline of the proposal.
- 2) Response to questionnaire, cross-referenced to supporting documents where applicable.
- 3) Supporting documents.
- 4) List of submitted materials, cross-referenced.

We would welcome a draft (2 copies) of your submission for informal comment if you so desire. However, for formal consideration by the SUMEX-AIM Advisory Group, please submit 13 copies of the material requested above in final form.

Elliott Levinthal, Ph.D.
AIM User Liaison
SUMEX-AIM Computer Project
c/o Department of Genetics, S047
Stanford University Medical Center
Stanford, California 94305

May, 1975

SUMEX-AIM RESOURCE

QUESTIONNAIRE
FOR POTENTIAL USERS

Please provide either a brief reply to the following or cite supporting documents.

A) MEDICAL AND COMPUTER SCIENCE GOALS

- 1) Describe the proposed research to be undertaken on the SUMEX-AIM resource.
- 2) How is this research presently supported? Please identify application and award statements in which the contingency of SUMEX-AIM availability is indicated. What is the current status of any application for grant support of related research by any federal agency? Please note if you have received notification of any disapproval or approval, pending funding, within the past three years. Budgetary information should be furnished where it concerns operating costs and personnel for computing support. Please furnish any contextual information concerning previous evaluation of your research plans by other scientific review groups.
- 3) What is the relevance of your research to the AI approach of SUMEX-AIM as opposed to other computing alternatives?

B) COLLABORATIVE COMMUNITY BUILDING

- 1) Will the programs designed in your research efforts have some possible general application to problems analogous to that research?
- 2) What application programs already publically available can you use in your research? Are these available on SUMEX-AIM or elsewhere?
- 3) What opportunities or difficulties do you anticipate with regard to making available your programs to other collaborators within a reasonable interval of publication of your work?
- 4) Are you interested in discussing with the SUMEX staff possible ways in which other artificial-intelligence research capabilities might interrelate with your work?
- 5) If approved as a user, would you advise us regarding collaborative opportunities similar to yours with other investigators in your field?

C) HARDWARE AND SOFTWARE REQUIREMENTS

- 1) What computer facilities are you now using in connection with your research or do you have available at your institution? In what respect do these not meet your research requirements?
- 2) What languages do you either use or wish to use? Will your research require the addition of major system programs or languages to the system? Will you maintain them? If you are committed to systems not now maintained at SUMEX, what effort would be required for conversion to and maintenance on the PDP-10 - TENEX system? What are the merits of the alternative plan of converting your application programs to one of the already available standards? Would the latter facilitate the objectives of Part B), Collaborative Community Building?
- 3) Can you estimate your requirements for CPU utilization and disk space? What time of day will your CPU utilization occur? Would it be convenient or possible for you to use the system during off-peak periods? Please indicate (as best you can) the basis for these estimates and the consequences of various levels of restriction or relaxation of access to different resources. SUMEX-AIM's tangible resources can be measured in terms of:
 - a) CPU cycles.
 - b) Connect time and communications.
 - c) User terminals (In special cases these may be supported by SUMEX-AIM.).
 - d) Disk space.
 - e) Off-line media-printer outputs, tapes (At most, limited quantities to be mailed.).

Can you estimate your requirements? With respect to a) and b), there are loading problems during the daily cycle.--Can you indicate the relative utility of prime-time (0900-1600 PST) vs. off-peak access?

- 4) What are your communication plans (TYMNET, ARPANET, other)? How will your communication and terminal costs be met? See following note concerning network connections to SUMEX-AIM.
- 5) If this is a development project, please indicate your long-term plans for software implementation in an applied context keeping in mind the research mission of SUMEX-AIM.

Our procedures are still evolving, and we welcome your suggestions about this framework for exchanging information. Needless to say, each question should be qualified a) "insofar as relevant to your proposal", and b) "to the extent of available information".

Please do not force a reply to a question that seems inappropriate. We prefer that you label it as such so that it can be dealt with properly in future dialogue.

Above all, we are eager to work with potential users in any way that would help minimize bureaucratic burdens and still permit a responsible regard for our accountability both to the NIH and the public. Please do not hesitate to address the substance of these requirements in the format most applicable to you.

NETWORK CONNECTIONS TO SUMEX-AIM

TYMNET

Attached is a list of available TYMNET nodes and associated telephone numbers. The cost to users of using TYMNET is the telephone charge from user location to the nearest TYMNET node. This is available only for communication to SUMEX-AIM and not for other facilities that may be connected to TYMNET. In some cases, there are "foreign exchanges" set up by users. These may offer less expensive communication. Details of these possibilities can best be learned by calling the nearest TYMNET node. The telephone company can provide information on comparative costs of leased lines, toll charges, etc. The initial capital investment for TYMNET installation as well as login and hourly charges is provided by SUMEX-AIM. Standard usage charges on TYMNET are approximately \$3/connect-hour.

ARPANET

SUMEX-AIM is connected to the ARPANET. Our name is SUMEX-AIM; our nickname is AIM. We support the new TELNET protocol. Our network address is decimal 56, octal 70. This provides convenient access for ARPANET Hosts and Associates and those who have accounts with ARPANET.

Attachment: Network service node access for TYMCOM-III users

May, 1975

APPENDIX J

Response to Congressional Inquiry

The following is in response to a congressional inquiry to NIH-BRB about aspects of the SUMEX-AIM resource. The questions posed include:

- 1) How much of the SUMEX resource is funded by NIH-BRB?
- 2) How many units (projects and individuals) are supported by the resource?
- 3) What is the cost per unit in operating the resource?

- 1) The SUMEX-AIM resource is essentially wholly funded by NIH-BRB.[*] The various collaborator projects which use SUMEX are independently funded with respect to their manpower and operating expenses. They obtain from SUMEX, without charge, access to the computing and, in most cases, communications facilities in exchange for their participation in the scientific and community building goals of SUMEX.

[*] Except for the participation by Stanford University in accordance with general cost-sharing, and for assistance to SUMEX by other projects with overlapping aims and interests.

- 2) The available SUMEX-AIM resource capacity is allocated to a variety of projects engaged in advanced computer science research (artificial intelligence) applied to medical problems. These are divided into three main groups: the projects local to the Stanford medical community (40% of the resource), the projects representing research efforts at other centers around the country (40%), and the resource development and operations staff (20%). The following gives a brief summary of the complement of projects with approximate size indicated by the total number of project members with access privileges to SUMEX and the number who were active during the latest statistics period of March. The list includes the current group of projects and may be expected to expand by 50-100% over the next year before the resource capacity is consumed. Note that each project, and in many cases each named user-member may in fact represent the efforts of from 1 to perhaps as many as 5 people sharing the same account.

SUMEX-AIM (National Group of Projects)

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	Total Members	Active Members
i) AIM Community Management and Committees[*]		
Full members	8	3
Staff	5	4
ii) DIALOG Project		
Prof. Pople		
Univ. of Pittsburgh	3	3
iii) Distributed Data Bases		
Prof. Kuo		
Univ. of Hawaii	2	1
iv) Higher Mental Functions		
Prof. Colby		
Univ. Calif. at LA	4	1
v) Medical Information Systems		
Prof. McCormick		
Univ. of Illinois	8	3
vi) Computers in Biomedicine		
Prof. Amarel		
Rutgers University		
Local users	27	24
Remote users	11	4
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TOTALS	68	43

[*] There are several additional committee members representing the user community. They are not counted under AIM management, but rather under their appropriate user project heading.

SUMEX-SUMC (Stanford Group of Projects)

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	Total Members	Active Members
i) DENDRAL Project		
Prof. Djerassi, Feigen-		
baum, and Lederberg		
Local users	31	21
Remote users	9	6
ii) Information Proc Psych.		
Prof. H. Cohen and		
Feigenbaum	2	1
iii) MYCIN Project		
Prof. S. Cohen and Dr.		
Buchanan		
Local users	10	5
Remote users	4	2
iv) Protein Structure Modeling		
Prof. Freer (Univ. Calif.		
at SD) and Dr. Engelmores		
(Stanford)	4	4
v) Pilot Projects	13	6
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TOTALS	73	45

SUMEX-SYSTEM AND STAFF (Development and Operations)

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	Total Members	Active Members
i) Develop. and Opns		
Staff	30	22
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TOTALS	30	22
	=====	=====
GRAND TOTALS	171	110

- 3) The cost per unit is difficult to state in a meaningful way as the usage load varies from project to project and from individual to individual. The following are gross averages computed from the estimated budget of the SUMEX-AIM project over the 5 year period of the grant award and the current user project load. Note that the project is still young and growing with respect to the user community and one may expect the number of users to increase by 50-100% over the next year without an increase in estimated project costs. This reflects the fact that the computer is not completely loaded with the present complement of users.

Project budget (5 years) [*]

Equipment purchase	\$1,000,000
Operating budget (manpower, supplies, etc.)	\$2,245,000

	\$3,245,000

[*] Note these funds include approximately \$100,000 per year allocated in reserve for communication usage and inter-project collaborative linkages.

This total figure is equivalent to \$649,000 per year, uniformly spreading the project costs over 5 years.

If we do not count the resource development and operations usage (which may be considered overhead in terms of medical applications), the total number of projects currently on the system is 11 (6 from the national community and 5 from Stanford). Furthermore, counting only the active users as of the March data, we have 88 people accessing the resource for research computing related to AI in medicine.

Thus, the annual costs per unit based on the current initial loading are:

\$59,000 per project per year

\$7,375 per user per year

As the user community grows by 50-100%, these unit costs will drop by 30-50%.

It should be stressed that the SUMEX-AIM management is actively involved at the present time in identifying and evaluating several additional significant projects, and that we believe that the number of projects will be substantially augmented during the next 12 months. However, the existing projects having been defined as major, on-going sites of significant research in this field are expected to continue to play a leading role in the usage statistics.

Besides the primary research activities and the corresponding users, projects like Stanford's "DENDRAL" and "MYCIN" and Rutgers's "Computers in Biomedicine" are actively dedicated to involving remote users scattered throughout the country, and using the data network facilities for the coordination of research.

***** ADDED NOTE OF EXPLANATION *****

The people at SUMEX are happy to display the figures just given in the terms requested. However, they believe that this calculation, though obviously useful for one form of managerial perspective, may neglect some special aspects of the SUMEX-AIM experiment. Considerable effort is being devoted by the staff at SUMEX to the technical and managerial tasks of making complex computer programs more readily available and useful to a wide range of prospective users which ultimately will exceed those who are actually connected directly to the system. The SUMEX-AIM system from the start has been founded on the idea that it was necessary to build a new kind of community effort so that workers at distant sites would be able to cooperate efficiently in the solution of very complex problems. To do this requires a great deal of dedication, effort and imagination in the service of others, which is not measured by the numbers of dollars spent per active user at a given time, but by the eventual cumulative value of this pattern of research. The cost of computer access per user is believed to be quite reasonable; and every effort is made to temper this in relation to the highest-priority needs of the community it serves. However, the design of SUMEX was not founded on the idea of producing the maximum number of computer cycles per dollar or per investigator, regardless of the results that these achieve, but rather to demonstrate a cooperative mode of resource-sharing that would generate the most creative research outcomes from the aggregate efforts of its workers.

Already, its users have given many testimonials to the much enhanced efficiency with which they can pursue their work in computer science applications in medical research as a consequence of this way of working in close inter-communication.